

Engineering Design File

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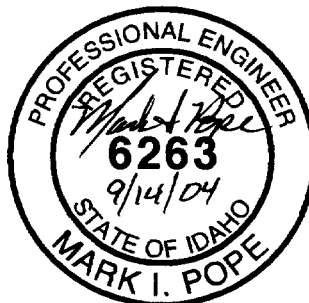
V-Tanks Contents Remediation Mechanical Design



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CONTENTS

1.	INTRODUCTION	4
2.	PURPOSE	4
3.	CONTENTS REMOVAL SYSTEM.....	4
3.1	Contents Removal Sequence	4
3.2	Contents Removal Pump Design.....	5
3.2.1	Requirements:	5
3.3	Contents Removal Piping System Design	5
3.4	V-3 Supernate Suction Design	7
3.5	V-1, V-2, and V-3 Moveable Suction.....	8
3.6	V-1, V-2, and V-3 Sump Suction	9
3.7	V-9 Suction.....	9
3.8	Suction Manifold	9
3.9	Discharge Piping	9
4.	V-TANKS VENTILATION REQUIREMENTS	9
4.1	Ventilation Criteria.....	10
4.2	Ventilation Calculations	10

V-Tanks Contents Remediation Mechanical Design

1. INTRODUCTION

This project will remove the contents from four buried waste tanks, remove the tanks themselves and associated piping, and remove contaminated soils surrounding the tanks. The tanks are located at Test Area North (TAN) on the Idaho National Environmental and Engineering Laboratory (INEEL). The tanks included are V-1, V-2, V-3, and V-9.

The project will transfer sludge and liquid from the four buried tanks to three new consolidation tanks located in a relocated weather enclosure north of TAN-666. The four buried tanks will then be removed from the ground and transported to the Idaho CERCLA Disposal Facility (ICDF) located near the Idaho Nuclear Technologies and Engineering Complex (INTEC). The contaminated soils surrounding the tanks will be excavated and stockpiled for future transport to the ICDF. The liquid and sludge will be treated and transported to ICDF by another phase of the project.

Tank V-1 is a 10,000-gal stainless steel storage tank. This tank contains approximately 520 gal of sludge under approximately 1,164 gal of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-2 is a 10,000-gal stainless steel storage tank. This tank contains approximately 458 gal of sludge under approximately 1,138 gal of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-3 is a 10,000-gal stainless steel storage tank. This tank contains approximately 652 gal of sludge under approximately 7,660 gal of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-9 is a 400-gal stainless steel storage tank. This tank contains approximately 250 gal of sludge under approximately 70 gal of liquid.

2. PURPOSE

This EDF contains the engineering design information including process description, vendor literature, and design calculations for the mechanical portions of the design. The purpose for this EDF is to present the design for information and clarification of the design package, and to be a reference for beginning the system operating procedures.

3. CONTENTS REMOVAL SYSTEM

3.1 Contents Removal Sequence

The following sequence contains a listing of events for contents removal of V-1, V-2, V-3, and V-9. The sequence assumes that excavation has occurred, and V-1, V-2, and V-3 tank nozzle flanges are exposed.

NOTE: *The following steps need not be performed in sequence, and may be performed out of the order listed in accordance with operations and project direction.*

1. Remove Supernate from V-3: Pump supernate liquid (approximately 6,000 gal) from V-3 to a supernate storage tank.

2. Remove Contents and Wash V-9: Pump sludge from V-9, using V-3 supernate as a sludge liquefier and spray wash. Use V-3 supernate to wash walls of V-9. Use clean water (if needed) to rinse V-9.
3. Remove Sludge From V-1, V-2, and V-3: Remove sludge from V-1, V-2, and V-3 (order not critical) with moveable suction system.
4. Remove Remaining Supernate from V-1, V-2, and V-3: Pump remaining water and sludge in V-1, V-2, and V-3 from the sump suction line. Circulate as necessary through wash wands.
5. Wash Tanks V-1, V-2, and V-3 with Clean Supernate/Clean Water: Use V-3 supernate to wash walls of V-1, V-2, and V-3. Use clean water (if needed) to rinse V-1, V-2, and V-3.

3.2 Contents Removal Pump Design

3.2.1 Requirements:

1. Pump liquid, sludge, slurry, and solids up to 3/4in. diameter.
2. Pump 6000 gal of water (V-3 supernate) in less than one shift (8 hours working time).
$$Q = V/t = \{(6,000 \text{ gal}) / (8 \text{ hr})\}(1 \text{ hr} / 60 \text{ min}) = 12.5 \text{ gpm (minimum for water)} \rightarrow \text{Use 20 gpm}$$

3. Pump 1,500 gal of sludge/liquid mixture (V-1, V-2, and V-3 each) in one shift (8 hours).
$$Q = V/t = \{1,500 \text{ gal}\} / (8 \text{ hr})\}(1 \text{ hr} / 60 \text{ min}) = 3.1 \text{ gpm (minimum for sludge)} \rightarrow \text{Water limits}$$

4. Pressure as required to deliver desired flows.

From Piping System Design calculations below, pipe is 1in. diameter.

From Piping System Design calculations below, supernate pumping requirements are 20 gpm at 40 psig.

Assume sludge is mixed with water for pumping. Assume pressure losses for sludge are 3 times water losses. From Piping System Design calculations below, sludge/supernate mixture pumping requirements are 20 gpm at 80 psig.

5. Vertical suction lift of 15 ft minimum.
6. Reversible to back flush clogged suction tube (or valve arrangement for back flush from supernate system).
7. Variable speed or capable of being throttled to vary flow.

The following pump is available to the project: Watson Marlow Model SPX-40 High-Pressure Hose Pump. This pump is a parastaltic type pump with a 5 hp variable speed reversible drive, capable of delivering water in excess of 20 gpm at 100 psig under continuous operation. \rightarrow This pump is acceptable.

3.3 Contents Removal Piping System Design

1. Velocity between 5 and 10 fps to keep solids (sand and dirt) mixed and flowing with the liquids.

At 20 gpm, choose pipe size to obtain between 5 fps and 10 fps velocity.

$V = 4.29$ ft/sec for 1 1/4in. pipe → Too slow.

$V = 7.43$ ft/sec for 1in. pipe → Acceptable.

$V = 12.03$ ft/sec for 3/4in. pipe → Pipe too small for solids.

Choose 1in. pipe with velocity of 7.43 ft/sec

2. Working pressure up to 100 psig.
3. Abrasion resistant for sludge and slurry applications.
4. Resistant to radiation and chemicals (see Sam Ashworth EDF, this project).
5. Calculate Pressure Drop:

Supernate (water) Pressure Drop:

$$Q = 20 \text{ gpm}$$

$$\text{Velocity} = 7.43 \text{ ft/sec}$$

$$f = \text{friction factor} = 0.015 \text{ (Crane TP-410 for complete Turbulence in 1in. Drawn Tubing)}$$

Pump pressure will include suction side and discharge side losses as follows:

Total Head = Static Head + Dynamic (Velocity) Head + Friction Head + Minor Losses

$$\begin{aligned} \text{Static Head} &= (\text{Highest piping on Consol. Tank}) - (\text{V-3 Tank Bottom} - 2 \text{ ft.}) \\ &= (4804 \text{ ft}) - (4762 \text{ ft} - 2 \text{ ft}) \\ &= \mathbf{44 \text{ ft}} \end{aligned}$$

$$\begin{aligned} \text{Dynamic Head} &= v^2/2g \\ &= (7.43 \text{ ft/sec})^2 / [(2)(32.2 \text{ ft/sec}^2)] \\ &= \mathbf{0.86 \text{ ft}} \end{aligned}$$

$$\begin{aligned} \text{Friction Head} &= f (L/D) (v^2/2g) \\ &= (0.015) [(300 \text{ ft})/(1/12 \text{ ft})] [0.86 \text{ ft}] \\ &= \mathbf{46.4 \text{ ft}} \end{aligned}$$

Minor Losses= Negligible for HDPE Pipe with minimal valves and fittings

$$\begin{aligned} \text{Total Head} &= 44 \text{ ft} + 0.86 \text{ ft} + 46.4 \text{ ft} = 91.3 \text{ ft} \\ &= (91.3 \text{ ft})(1 \text{ psi} / 2.3 \text{ ft}) = 40 \text{ psi} \end{aligned}$$

→ **Supernate pumping requirements are 20 gpm at 40 psig.**

Sludge/Supernate Pressure Drop:

Assume that the sludge/supernate mixture is 3 times more difficult to pump (friction factor 3 times that of water). The new pumping requirements for the sludge/supernate mixture is as follows:

$$\text{Velocity} = 7.43 \text{ ft/sec}$$

$$f = \text{friction factor} = (0.015)(3)$$

Pump pressure will include suction side and discharge side losses as follows:

Total Head = Static Head + Dynamic (Velocity) Head + Friction Head + Minor Losses

$$\begin{aligned}\text{Static Head} &= (\text{Highest piping on Consol. Tank}) - (\text{V-3 Tank Bottom} - 2 \text{ ft.}) \\ &= (4804 \text{ ft}) - (4762 \text{ ft} - 2 \text{ ft}) \\ &= \mathbf{44 \text{ ft}}\end{aligned}$$

$$\begin{aligned}\text{Dynamic Head} &= v^2/2g \\ &= (7.43 \text{ ft/sec})^2 / [(2)(32.2 \text{ ft/sec}^2)] \\ &= \mathbf{0.86 \text{ ft}}\end{aligned}$$

$$\begin{aligned}\text{Friction Head} &= f (L/D) (v^2/2g) \\ &= (0.015)(3) [(300 \text{ ft})/(1/12 \text{ ft})] [0.86 \text{ ft}] \\ &= \mathbf{139.2 \text{ ft}}\end{aligned}$$

Minor Losses= Negligible for HDPE Pipe with minimal valves and fittings

$$\begin{aligned}\text{Total Head} &= 44 \text{ ft} + 0.86 \text{ ft} + 139.2 \text{ ft} = 184.1 \text{ ft} \\ &= (184.1 \text{ ft})(1 \text{ psi} / 2.3 \text{ ft}) = 80 \text{ psi}\end{aligned}$$

➔ **Sludge/Supernate pumping requirements are 20 gpm at 80 psig.**

3.4 V-3 Supernate Suction Design

This system will be used to pump approximately 6,000 gal of supernate from V-3 prior to removing contents from any other tank.

Pump suction will be screened to prevent debris from entering this system. The suction will be a floating suction to allow pumping the clean supernate with minimal disturbance of the underlying sludge.

Use Parker Series 7570 Dynaflex PVC Transparent Suction/Discharge hose, 1-1/2in. hose size.



Use Megator Corporation Dolphin Floating Suction Strainer, 1-1/2in. Hose Size.



Type	Hose Size	Strainer Diameter	Strainer Height	Max. Capacity
1 1/2in.	1 1/2in.	5 3/4in.	7 3/8in.	37 US gpm
	38mm	146mm	162mm	140 lt/min

3.5 V-1, V-2, and V-3 Moveable Suction

Sludge from the bottom of V-1, V-2, and V-3 will be removed under the existing clear water (approximately 1,000 gal in each tank) with the moveable suction line, acting much like a vacuum cleaner wand. The moveable suction will be composed of 3 major components: A Manual Extension Rod, Suction Nozzle, and Suction Hose.

The manual extension rod will be a 1 3/4in. diameter aluminum concrete float extension handle, with four 6 ft. sections. The extension rod will reach to both ends of the tanks through the existing 20in. diameter manholes on each tank. The rod will be manipulated manually from above the tanks. Temporary shielding for the operators may be required, and will be evaluated by radcon personnel during operations.



The suction nozzle is designed to simply provide a scooping action at the end of the suction wand. The suction inlet will be a 3/4in. hole in the suction scoop to provide a screening action and also provide a slight nozzle action when the water flow is reversed. The suction nozzle will be fabricated of 3in. diameter pipe, cut in half lengthwise to form a "C" shape. The suction pipe will be welded to the suction nozzle, and the extension handle will be banded to the suction pipe.

The suction hose will be routed through the existing 3in. diameter vent nozzle on each tank. The hose will be lowered into the tanks (above the water and sludge) to a point where a hook on an extension rod can be used from the manhole to bring the hose end back up to the manhole. The hose will then be connected to the suction nozzle and manual extension rod, and the assembly will be lowered into the sludge. The suction hose will be transparent to allow for operators to see the contents flow.

Use Parker Series 7570 Dynaflex PVC Transparent Suction/Discharge Hose, 1in. hose size.

3.6 V-1, V-2, and V-3 Sump Suction

The sump suction will be located in the existing tank sump. A suction tube (4in. schedule 40 stainless steel pipe) currently extends from the existing suction nozzle to within 6in. of the bottom of the sump. The new suction line will be inserted into the existing suction tube and will extend below the suction tube into the sump. The suction hose will be transparent to allow for operators to see the contents flow. Suction hose will be Parker Series 7570 Dynaflex PVC Transparent Suction/Discharge Hose, 1in. hose size (see photo above).

It is expected that solids will be encountered in the V-1, V-2, and V-3 tank sludge. Although sludge characteristics are identified, the exact solids material and solids size is not known. The pump utilized is capable of pumping some solids, but transport of those solids through the system becomes a concern with larger solids. To prevent problems with solids transport through the system and to prevent inlet piping plugging, the suction end of the hose will be capped with a pipe cap with a 3/4in. diameter hole drilled in the end of the cap. This will prevent solids greater than 3/4in. from entering the suction system, and will provide a slight nozzle action for back-flushing operations.

3.7 V-9 Suction

The suction line from V-9 will be a 1in. pipe inserted into the existing 6in. vent line in the top of V-9. The pipe will be galvanized carbon steel. The suction line elevation will be adjustable, with a pipe riser clamp attached to the suction pipe to maintain the desired height.

The suction line will be attached to a transparent suction hose above grade to allow for operators to see the contents flow. Suction hose will be Parker Series 7570 Dynaflex PVC Transparent Suction/Discharge Hose, 1in. hose size (see photo above).

3.8 Suction Manifold

The suction hoses from each of the above suction locations will be connected to a suction manifold consisting of the valves and piping necessary to allow for operation of any of the suction sources from any of the tanks. Suction piping will be single wall 1in. diameter DriscoPlex 3408 series HDPE piping for abrasion resistance. The piping will be SDR-9.0 to help withstand vacuum pressures. Manifold valves will be 1/4 turn ball valves.

3.9 Discharge Piping

Discharge piping from the tank suction pump to the consolidation tanks will be DriscoPlex 3408 series HDPE piping for abrasion resistance. The pipe will be SDR-9.0 for pressures up to 200 psig. The pipe will be encased within a 4in. DriscoPlex 4100 series HDPE pipe from the pump discharge to the consolidation tank skid. Piping within the consolidation skid will not be encased.

4. V-TANKS VENTILATION REQUIREMENTS

Ventilation of the V-tanks is required to help reduce the release of VOC's and radioactive contaminants from the tanks during the contents removal operations. These operations will include moving sludge, mixing, spraying, and washing of the tanks with supernate and tank contents which may contain VOC's and radioactive contaminants.

The ventilation system is being designed and provided by others. This section is only to provide a recommended flow rate for ventilation of the tanks during contents removal.

4.1 Ventilation Criteria

Capture Velocity: 150 ft/min inward face velocity through any opening in the tank.

Anticipated Openings: It is anticipated that a manhole and one 6in. diameter nozzle will be open at any time. Other openings will be plugged, capped, or taped.

4.2 Ventilation Calculations

$$V = 125 \text{ ft/min}$$

$$A_{MH} = (\pi)(d)^2/4 = (\pi)(20/12 \text{ ft})^2(1/4) = 2.18 \text{ ft}^2$$

$$A_{6"} = (\pi)(d)^2/4 = (\pi)(6/12 \text{ ft})^2(1/4) = 0.20 \text{ ft}^2$$

$$Q_{MH} = VA_{MH} = (125 \text{ ft/min})(2.18 \text{ ft}^2) = 273 \text{ ft}^3/\text{min}$$

$$Q_{6"} = VA_{6"} = (125 \text{ ft/min})(0.20 \text{ ft}^2) = 25 \text{ ft}^3/\text{min}$$

$$Q_{\text{Total}} = Q_{MH} + Q_{6"} = 273 \text{ ft}^3/\text{min} + 25 \text{ ft}^3/\text{min}$$

$$Q_{\text{Total}} = \mathbf{298 \text{ ft}^3/\text{min}}$$

It is understood that polyethylene covers will be in place over the manholes during most of the spraying operations. The above flow rate will allow for the cover to be removed while still maintaining an appropriate capture velocity within the tanks. Once the openings are covered, the flow rate can be reduced.

NOTE: *It has been found that velocities significantly lower or significantly higher than the target 125 ft/min actually create problems. Higher and lower velocities cause eddies at the entrance faces that pull contaminants from the containment. Some of the contaminants within the V-tanks will be lighter than air when disturbed. They will collect at the top of the tanks where they will escape if the capture velocities are not correct. Therefore, it is important that the face velocity at each opening be monitored closely by safety personnel to ensure that each velocity is acceptable.*